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**Median Lethal Concentration and Efficacy of *Bacillus Thuringiensis* Against Banded Sunflower Moth (Lepidoptera: Tortricidae)**

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ABSTRACT
This study was conducted to determine dose-mortality response of the banded sunflower moth, *Cochylis hospes* Walsingham, to *Bacillus thuringiensis* Berliner and its effect on sunflower seed damage and yield. Of *B. thuringiensis* products tested, Cutlass AF and Javelin WG had the lowest LC50 values and highest slopes and relative potencies for *C. hospes*. Javelin WG was superior to the other *B. thuringiensis* materials tested and to Asana XL in preventing seed damage. Sunflower heads sprayed with Javelin WG had higher yields than sunflower heads sprayed with Asana XL or the other *B. thuringiensis* products tested. Asana XL is a standard chemical insecticide and is considered to give good control of banded sunflower moth. As an alternative to Asana XL, any of the *B. thuringiensis* products tested could be employed for control of *C. hospes* larvae and to reduce the impact on beneficials in sunflower fields.

KEY WORDS *Cochylis hospes*, *Helianthus annuus*, *Bacillus thuringiensis*
within the rows. The plots were equivalent to 47,000 plants per hectare. There was a 2.5-m fallow area between plots and 3.5-m fallow areas between blocks. Treatments were arranged in a randomized complete block design with 4 replications. Standard cultivation practices for this location were used to maintain the plants. When sunflower capitula were at bloom stage (R5.1–5.3, Schneider and Miller 1981), insecticide treatments were applied using a tractor-mounted boom sprayer (40 psi, S-11004 nozzles, 1,700 rpm, 117 liters of H2O/ha).

At physiological maturity (R9), sunflower heads from 5.3 m of the 2 center rows of each plot were hand-harvested, oven-dried, hand-threshed, and the seeds were hand-cleaned by manually removing debris. Ten samples (100 seed each) were selected randomly from each plot and were evaluated for the percentage of banded sunflower moth damaged seeds. In addition, 10 samples (100 seed each) were selected randomly from each of the 4 replicates and weighed to determine seed yields per treatment.

Statistical Analysis. Dose-mortality response data from the bioassays were tested by probit analysis (LeOra Software 1987). POLO-PC uses Abbott’s formula to incorporate control mortality (Abbott 1925). The chi-square value was used to measure the goodness-of-fit of the probit regression line to the points. PROC univariate, residual analysis was used to check if the variables for the field data met assumptions of analysis of variance. Data were analyzed using the general linear model (SAS Institute 1995), and means were compared by using least significance difference least significant difference (P < 0.05).

Results and Discussion

Bioassay Experiments. Banded sunflower moth dose-mortality responses to the tested B. thuringiensis products are summarized in Table 2. The dose-mortality relationship of an insect to a toxin is typically expressed as an LC50 value, which is the toxin concentration required to kill 50% of the population in a specified period. The lower the LC50 value, the greater the toxicity. Cutlass AF and Javelin WG (wettable granules) had the lowest LC50 values, suggesting that they were more toxic to C. hospes larvae than Cutlass WP (wettable powder, Thuricide AF, and Condor OF with the highest LC50 values. However, the LC50 alone does not reveal an accurate picture of the total pathogenic effect. Insects respond to increasing doses of pathogenic organisms by increased infection and mortality, just as they respond to increased doses of insecticides (Metcalfe and Luckman 1994). Therefore, the mortality effect of an insect pathogen on its host can be expressed as an LC50 value and can also be characterized by the slope of the log-probit curve. The slope of the dose-mortality curve is a measure of variability in response to treatment within the insect population tested. As the value of the slope increases, mortality associated with changes in concentration increases. Conversely, as the value of slope decreases, less change in mortality is seen per unit change in concentration of the mortality agent. Insect pathogens, such as polyhedrosis viruses, have slopes of 0.56 or less, whereas insecticides, such as DDT, have slopes of 5.5 or greater (Metcalfe and Luckman 1994). Insect pathogens that produce toxins, such as B. thuringiensis, are usually characterized by intermediate slopes of ~2.58 (Bucher 1960, Burges and Thomson 1971). The slopes of the dose-mortality curves for Cutlass AF and Javelin WG were 2.02 and 1.07, respectively, suggesting that these products have some toxicity to the banded sunflower moth and do not rely, at least solely, on infection to cause mortality.

Relative potencies are used to compare the degree of effectiveness of various B. thuringiensis materials against a standard. We compared all the B. thuringien-
sis formulations against Dipel WP 2X. A relative potency > 1 indicates the product was more toxic to 1st-instar banded sunflower moth larvae than was Dipel WP 2X. Cutlass AF and Javelin WG had the highest relative potencies and were the most efficacious materials tested against C. hoesper larvae.

**Field Experiments.** In general, the microbial and chemical insecticides were equally effective in limiting seed damage (Table 3). The one exception was sunflower treated with Condor OF in 1996, which had significantly more seed damage than the insecticide check, Asana XL. Insecticide treatments did not result in significant differences in seed weight and seed yields (Table 3) compared with controls for either year. This may be caused by the relatively low infestations both years. However, in 1996, but not 1995, Javelin WG had higher, although not significantly higher, yields than either Asana XL or the other B. thuringiensis products tested. Asana XL, a chemical insecticide, is a standard insecticide used on sunflower and is considered to give good control of banded sunflower moth. Although as an alternative to Asana XL, any of the B. thuringiensis insecticides tested could be used, those with lowest LC<sub>50</sub> values, and highest slopes and relative potencies would probably be most effective. The additional benefit from using B. thuringiensis is the absence of any adverse impact on natural enemies and insect pollinators.

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